Mapping and Modeling Fluorescence of Thin Stratified LNAPL, and Other Applications, Using the New High Resolution Optical Image Profiler (OIP) Tool

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Background/Objectives. High-resolution site characterization tools (HRSC) are now commonly used to investigate sites, both new, and those previously investigated with traditional methods. High vertical resolution tools are now available that can measure soil conductivity, relative VOC concentrations, lighter non-aqueous phase liquid (LNAPL) fluorescence, soil hydraulic properties, and other geotechnical parameters. Some tools were developed over 20 years ago, and new tools are being developed or improved all the time. The most recent tool to be developed that can be advanced using direct-push technology (DPT) is the Optical Image Profiler (OIP) tool. Most crude oils and refined petroleum hydrocarbons contain aromatic hydrocarbons that fluoresce under ultra-violet (UV) light. The primary application of this tool is using the fluorescent properties of petroleum hydrocarbon liquids to map subsurface accumulation of LNAPL. However, the tool has other applications using UV and visible light sources to capture images of the soil and pore fluids under both types of light.

Approach/Activities. The OIP tool provides data similar data to another HRSC tool that has been around for several years, the ultra-violet optical screening tool (UVOST®). The UVOST tool uses laser induced fluorescence (LIF) to excite the hydrocarbons in the soil and captures the data using fiber optics and a portable spectrometer combined with DPT. The OIP uses a UV light emitting device (LED) to produce the fluorescence, and captures the fluorescence using digital camera technology. Both the light source and the camera are built into a robust down-hole DPT tool that can withstand the pounding of a DPT percussion hammer rig. Electrical wiring carries the data to the surface where it is processed on data acquisition instruments and a computer. Images of fluorescing hydrocarbons are captured every 1/20th of a foot. The result is a boring log showing the continuous percentage of fluorescence from hundreds of captured images. The OIP tool also has a visible (white) LED source to capture images of the soil. In addition to detecting petroleum fluorescence, the vertical distribution of fluorescent tracer dyes can be seen, as can visible images of various injected reagents, such as carbon, or permanganate. Examples of HRSC data, and 3D models, show HRSC features such as LNAPL confined below an aquitard, tracer dyes, and reagent distribution.

Results/Lessons Learned. The OIP tools is a very robust tool who's primary application is mapping of both thick and thinly vertically distributed LNAPL. Layers of LNAPL can be resolved in a soil log as thin as 0.05 feet. Modeling these and presenting the data in three-dimensional (3-D) computer models requires an understanding how to set parameters in the modeling software so that they will resolve these LNAPL features at very high vertical resolution. Understanding the statistical distribution of such contaminants are log-normal, not linear, and applying that knowledge to the model by statistically transforming the data, creates model images that better represent the true distribution in the subsurface. Numerous log and model image examples will be presented.